Flight Test STEM Project

Dan Hrehov PE

danhrehov@outlook.com

Introduction

- Meaningful, authentic flight test project for science students
- Use industry tools and procedures
- Conduct actual takeoff flight test using a flight simulator
- Record and recover time history flight data for post flight analysis
- Use kinematic equations with speed and time to compute distance
- See effects on takeoff distance by varying airplane parameters such as gross weight, flaps, thrust
- Introduce Lift equation, Newtons equation etc.

Project Topics

- Anatomy of an airplane
- Reading flight instruments
- Airplane forces of flight
- Test planning including Risk Alleviation
- Lift and the Lift equations
- Data analysis utilizing plotting tools
- Unit conversions
- Dimensional analysis
- Distance equations using either average velocity or acceleration

Grade Level and Scalability

- Junior High
  - Gross weight evaluations
  - Xplane runway calculations
- High School
  - Student runway calculations
  - Flaps
  - Airport elevation and temperature
  - Winds
  - Thrust
- Duration
  - From three lab periods to a nine week class

Learning Standards

- Next Generation Common Core Science Standards
  - *MS-PS2-2: Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.*
  - 8EE.5 *Understand the connections between proportional relationships, lines, and linear equations. Graph proportional relationships, interpreting the unit rate as the slope of the graph.*

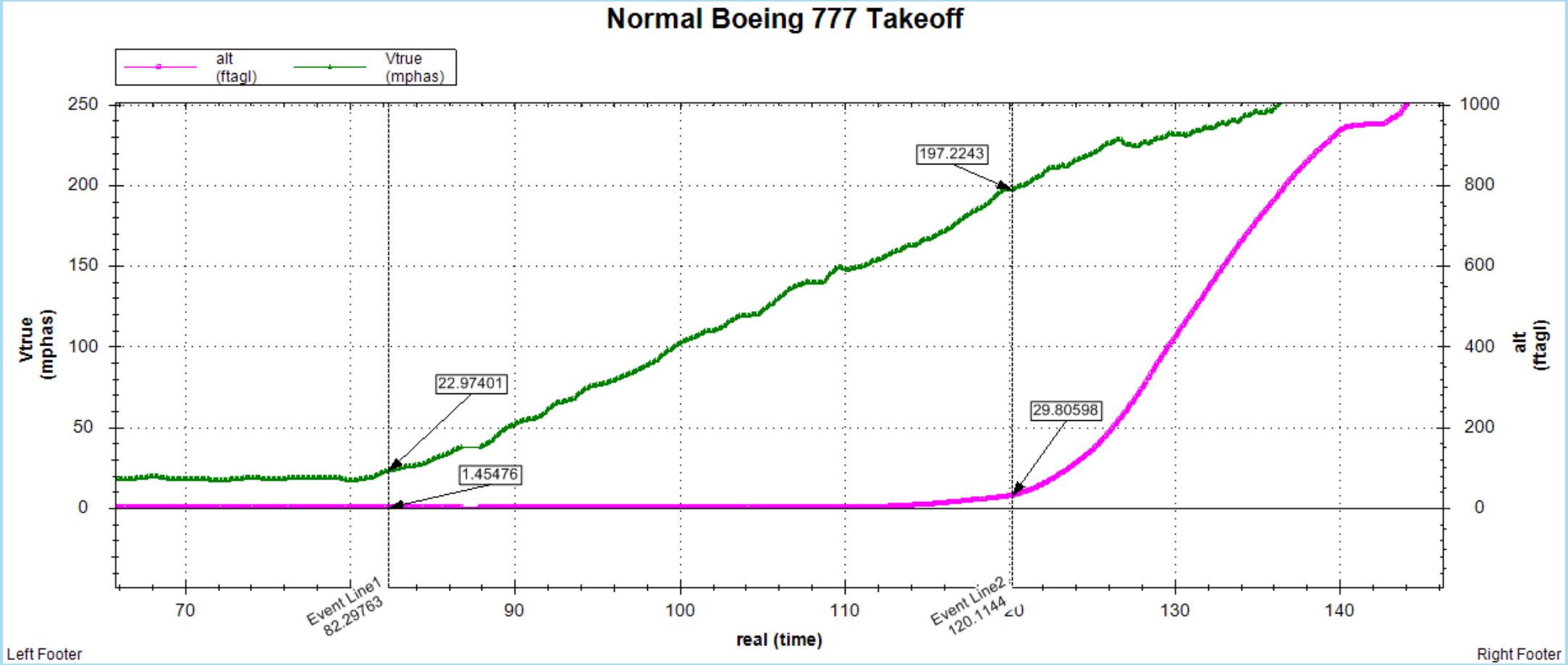
Math Connections

- Relationship between velocity, time and distance
- Units conversion
- Dimensional analysis used during units conversion
- Distance calculations using average velocity; $D = V_{ave}$*t, where $V_{ave} = (V_f + V_i)/2$
- Distance calculations using derived acceleration; $D = ½at^2$
- Lift Equation; $L = \frac{1}{2}\rho S V^2 C_L$
- Newton's Second Law; F=ma

Other Skills

- Test plan development including addressing test risk
- Test Discipline
  - Following test plan
  - Configuration
  - Data recording
- Data Analysis
  - Excel skills
  - Data manipulation
- Data Synthesis and Reporting

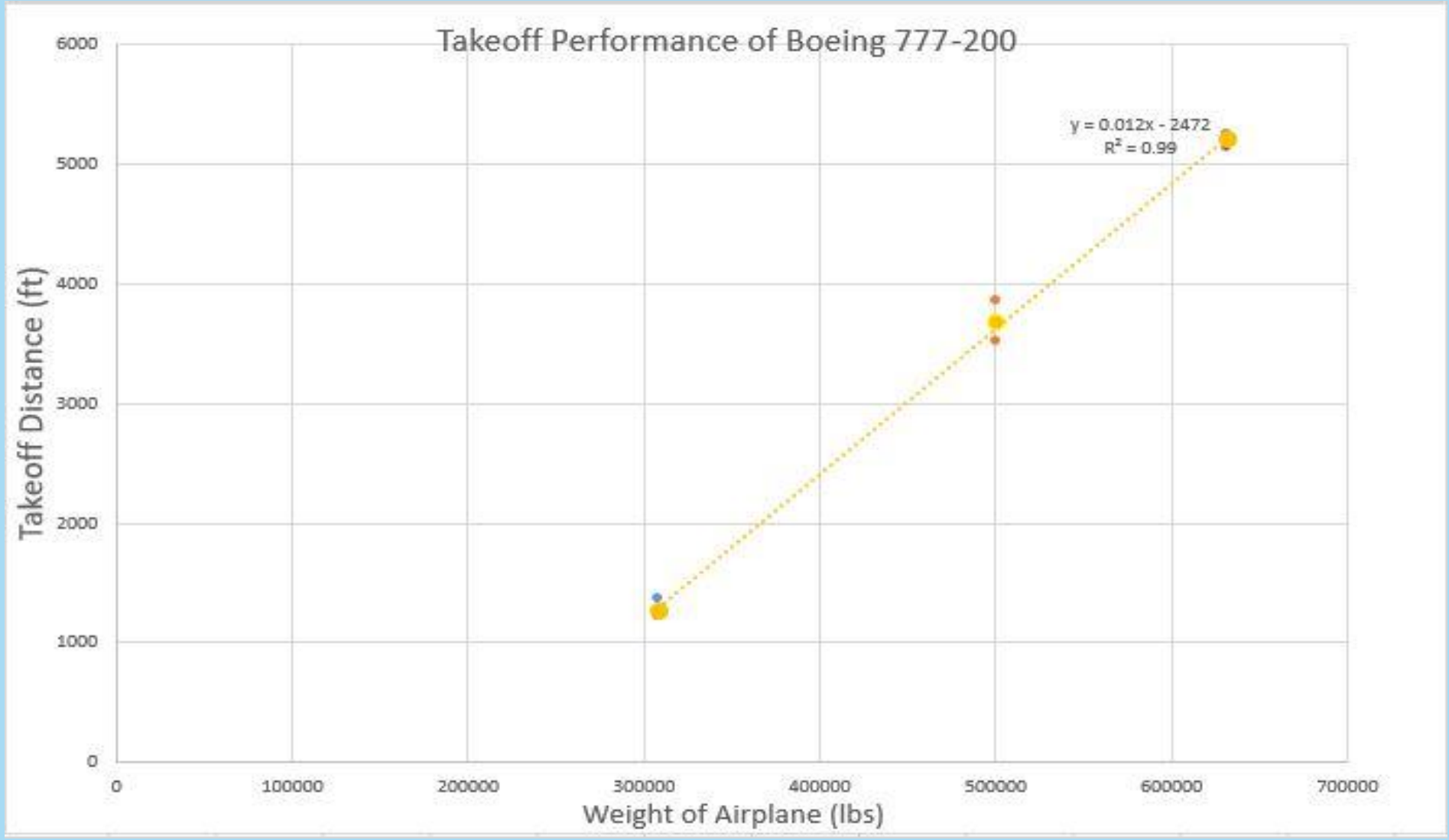
Example Takeoff Plot



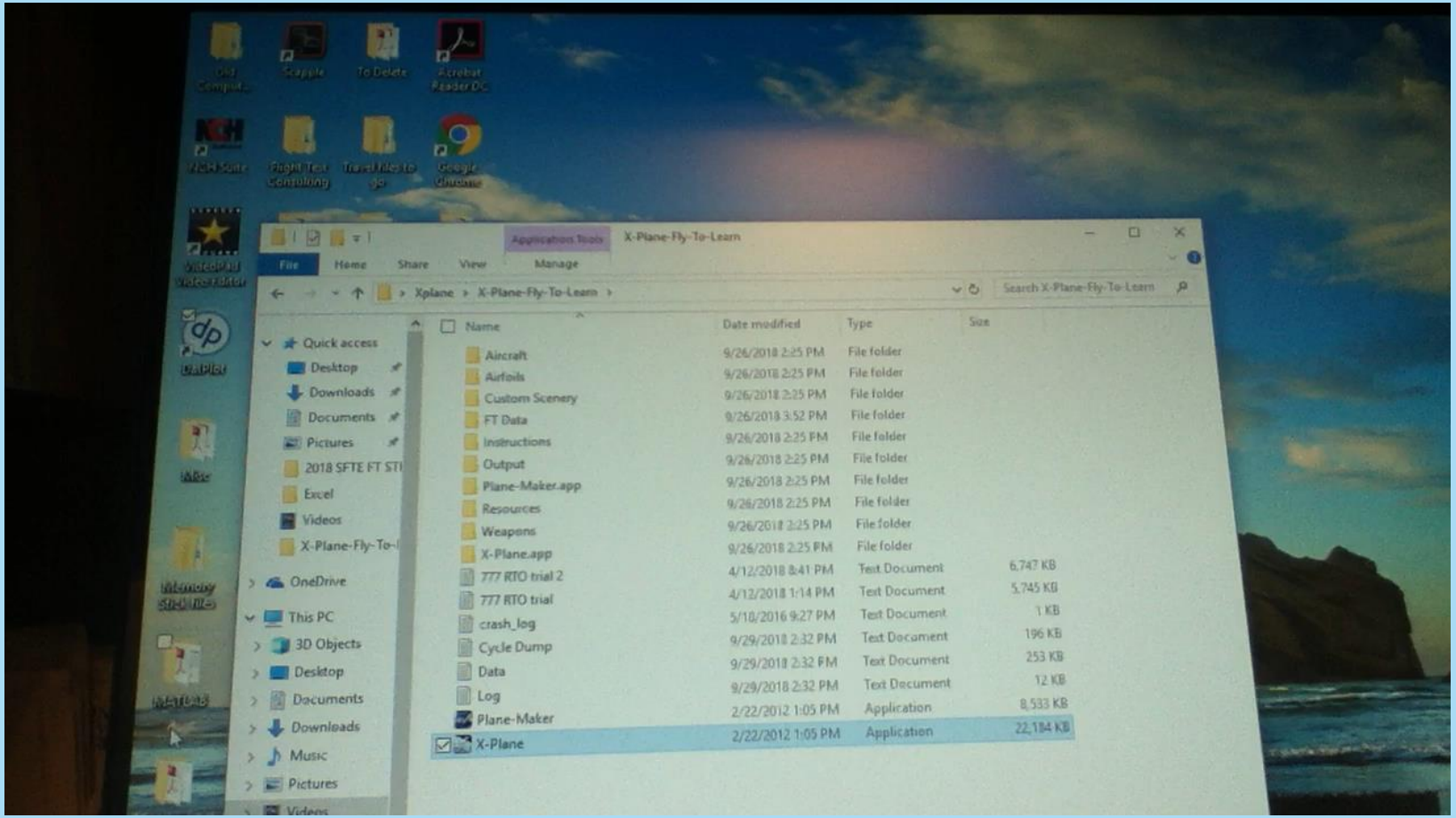
Data Summary Table for 777 Gross Weight

Cond	Weight (lbs)	$t_{\text{to reach 50 mph}}$ (s)	$t_{\text{take off}}$ (s)	Acc (ft/s per s)	Take-off distance (ft)
12.1	308,210	4.7	13.3	15.45	2950.93
12.2		4.7	12.4	15.72	2496.57
12.3		4.3	12.0	16.92	2386.51
13.1	500,237	5.4	23.2	13.61	3655.63
13.2		5.4	22.7	13.63	3514.86
13.3		5.4	23.9	13.49	3858.60
14.1	632,499	7.0	31.6	10.50	5248.20
14.2		7.0	31.6	10.52	5237.83
14.3		6.9	31.1	10.64	5130.11

Student Example of Results



Video of Example Test



How to Get Started

- Supplies
  - Laptop or desktop computer
  - Xplane version 9 demo for free at http://www.x-plane.com/desktop/try-it/older/
  - Excel spreadsheet software or a data plotting program such as DatPlot (http://www.datplot.com/
- Other Resources
  - *NASA Beginners Guide to Aeronautics* page https://www.grc.nasa.gov/WWW/k-12/airplane/index.html
  - *NASA What is Aeronautics* page https://www.grc.nasa.gov/WWW/k-12/UEET/StudentSite/aeronautics.html
  - Local SFTE Chapter

Next Steps

- Share this with a teacher, school, students etc.
- Provide assistance to teacher

Questions?